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CONTROLLING IMPORTANT FUNGOUS AND INSECT ENEMIES OF THE PEAR IN THE HUMID SECTIONS OF THE PACIFIC NORTHWEST

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Joint Contribution from the Bureau of Plant Industry
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PEAR GROWERS of the coast regions of Washington and Oregon can greatly increase the yields of their trees by careful spraying at the right time and with the proper materials. The losses occurring at present are largely due to pear scab and various insect pests.

This bulletin describes the more important fungous and insect enemies of the pear in the region mentioned and gives directions for combating them. It also tells how to prepare the spray materials needed and how to apply them. A spraying schedule, showing concisely when and with what to spray, is included.

CONTROLLING IMPORTANT FUNGOUS AND INSECT ENEMIES OF THE PEAR IN THE HUMID SECTIONS OF THE PACIFIC NORTHWEST.[1]

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PEAR GROWING IN THE PACIFIC NORTHWEST.

THE CULTURE of pears in that section of the Pacific Northwest located west of the Cascade Mountains (fig. 1) has become an industry of rapidly increasing importance. In the Willamette Valley, Oreg., there is a large acreage of established commercial orchards, while a considerable planting of young orchards has been made both in this section and in the Puget Sound region of western Washington, where older orchards are not so numerous. Pears thrive unusually well in these districts and have thus far not suffered from the pear-blight scourge that has handicapped the culture of this fruit in other sections of the Pacific Northwest. Pear growing in these districts has also been greatly stimulated by the development of canning factories, which provide a ready outlet for a considerable portion of the crop.

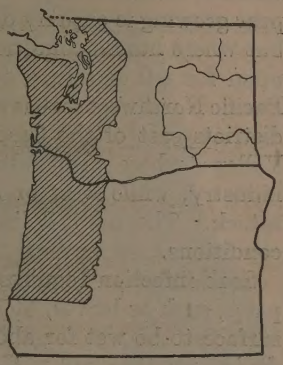

FIG. 1.—Outline map of Washington and Oregon, showing, by shading, the region covered by this bulletin.

The industry has, however, suffered severe loss and its development has been greatly handicapped by various insect pests, as well as by the prevalence of pear scab, a fungous disease. While spring and summer spraying of pears for the control of scab has been quite generally practiced, the results have often been disappointing, especially when spraying has not included an insecticide for the control of insects which cause a disfigurement that appears very much like scab spots when the pears are mature. It is the aim of this bulletin to present to the orchardist information which will enable him to recognize and distinguish these troubles and to take the necessary measures for their control.

[1] This bulletin applies particularly to that part of the State of Washington west of the Cascade Mountains and to the Willamette Valley and the northwestern part of Oregon.

PEAR SCAB.

Scab is the only fungous disease of importance occurring on pears in the region covered by this bulletin.

ECONOMIC IMPORTANCE.

Next to pear-blight, scab is the most serious disease to which the pear is subject. While it is readily controlled by sprays it annually causes a heavy loss because of inattention to spraying, inefficient spraying materials, careless methods of application, or failure to spray at the right time. The crop yield is frequently cut from 50 to 75 per cent, and unsprayed fruit is usually so unsightly that it is practically worthless for marketing. If greatly deformed it can not be disposed of even through the canneries.

INFLUENCE OF CLIMATIC CONDITIONS.

The economic importance of the disease varies greatly with the climatic conditions. Where the climate is strictly arid and where pear growing is entirely dependent upon irrigation, scab is not found; but where humid conditions prevail and natural rainfall is depended upon for soil moisture, scab must be contended with. Thus, in the Pacific Northwest scab is entirely absent from the hot interior irrigated districts east of the Cascades, such as the Yakima and Wenatchee Valleys, where pear culture has been developed into an extensive industry, while west of the Cascades every pear tree is subject to attack. The natural limitation of the disease is due to moisture conditions.

Scab infection requires moisture on the surface of the susceptible parts, such as leaves, blossoms, and fruit. Moreover, it requires the surface to be wet for about two days; mere dews or fogs followed by drying weather will not suffice, for although the spores may germinate, the subsequent drying kills the fungus before it has an opportunity to establish itself in the plant tissues. Frequent rains followed by muggy weather which does not permit the trees to dry create the most favorable condition for scab growth. This being true, it is to be expected that the severity of the disease will vary from year to year in accordance with the precipitation and that it will become more serious in seasons of prolonged rainfall, but be restricted during periods of drought.

The climate of western Washington and northwestern Oregon is peculiar in that the winters are very mild, with little snowfall but considerable rain. The spring is usually rainy, with some precipitation or fog during part of nearly every day. The summer, however, is prevailingly without rainy periods, with bright clear weather most of the time. With the coming of fall, however, rains begin again. Under such climatic conditions the greatest injury from pear scab

occurs early in the spring, but late attacks of the fungus often occur on fruit that does not mature before the fall rains. The early infection of the fruit results in the greatest disfigurement (fig. 2), as well as often preventing a crop from setting; consequently, it causes more loss than later attacks. During the summer season scab infection is less likely to occur and is entirely dependent on chance periods of rainy weather.

CHARACTER OF THE INJURY.

Pear scab is a fungous disease that attacks the fruit, foliage, and twigs. The greatest damage is done to the fruit, on which it produces the sooty-appearing spots so familiar to most orchardists. These spots are generally somewhat irregularly circular in outline, with a velvetlike appearance, black or olive green in color. In size the spots range from mere specks to areas that may cover the entire side of a young pear, while two or more spots may coalesce and increase the extent of the affected area (fig. 2). When very young pears are affected they may drop before they become one-half inch in diameter. The fungus causing the disease grows just beneath the cuticle, which becomes ruptured, exposing the epidermis, which is rendered corky on exposure, thus forming a roughened spot. Its effect is strictly local at first and causes no discoloration or hardening of the flesh beneath; but as the pear grows the scab injury restricts the expansion of the fruit and causes it to become distorted in shape, a most objectionable feature. If the normal growth of the fruit is greatly distorted, cracks may be formed which extend halfway around the pear and almost to the core.

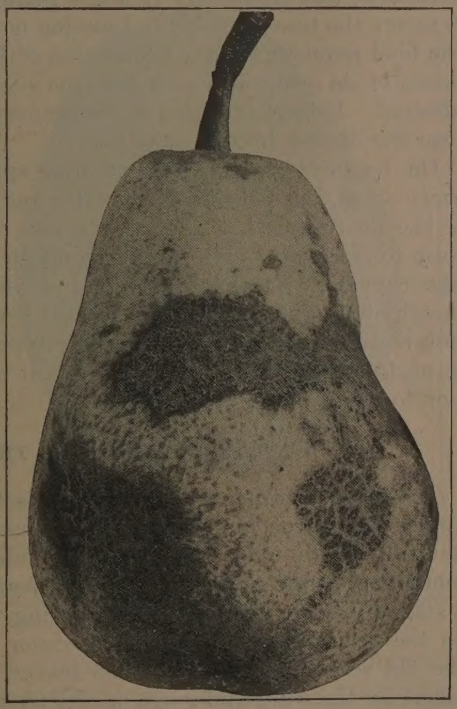

FIG. 2.—Scab on a mature Bartlett pear from infection occurring early in the season.

The infection of buds and blossoms on unsprayed trees is frequently severe and often results in a great reduction of the crop. Scab on the buds and blossoms is exhibited as dark, velvety, and sooty-appearing spots, much the same as on the young fruits, and infection may occur on any of the more exposed flower parts. Infection of the flower stalk is almost certain to prevent the fruit from setting.

Foliage infection frequently is not recognized by the orchardist, but it is one of the most serious manifestations of the disease. Infection occurs chiefly on the under side of the leaves and is exhibited as a dark olivaceous colored spot, similar to scab on the fruit. When many infections occur on a leaf it may become somewhat curled and deformed, and frequently it drops prematurely. If the defoliation is severe the tree is unable to function normally and can not store up the food requisite for the production of fruit buds and the maintenance of its own vitality; hence, the succeeding crop may be greatly affected. Foliage infection is also important as a means of carrying over the disease from year to year.

On tender twig growth scab first appears in the characteristic sooty spots, but persists over winter and eventually causes the bark to become ruptured, so that after a year or two the younger branches seem to be covered with small irregularly circular shaped and blister-like cankers. As the branch grows older these roughened areas slough off and healthy bark is formed over the injury. Twig infection is not as prevalent as the other types, but is likely to be found in neglected orchards. It is important chiefly as a source of infection for fruit and foliage.

THE FUNGUS CAUSING THE DISEASE.

The fungus causing the disease[1] is closely related to the well-known apple-scab fungus, but it is a different species. It persists over winter not only on the twigs but also on the fallen leaves. Infected leaves remaining on the ground over winter permit the fungus to complete a stage in its life history. In the spring, at about the time the buds on the pear trees are breaking, "winter spores" are matured from the old scab spots on the fallen leaves. These spores are wafted about by the wind and lodge on the tender buds and foliage, and if the moisture which is necessary for their germination is present infection proceeds and a new scab spot is formed. This new scab spot produces "summer spores" with great rapidity, mature spores being formed within two weeks if weather conditions are favorable. These "summer spores" thus rapidly reproduced serve as a constant source of infection throughout the season, and the fungus becomes established.

[1] *Venturia pyrina* Aderhold.

Spores matured on the twig cankers cause infection in the same manner or may be washed on to the fruit and foliage during rains.

The period of greatest infection is from the time the first buds appear until about a month after blossoming, or until summer weather is encountered. The cool wet weather which usually prevails during this period constitutes the most favorable climatic condition for the growth and dissemination of the fungus, while the new pear growth is very tender, permitting scab infection to be easily established. Hot, dry weather is very unfavorable to scab and it does not thrive after the period of spring rains, but if a period of wet weather is encountered later in the season new infections will be formed. If infection occurs when the fruit is about mature, small scab spots are produced, but no distortion occurs (fig. 3). Frequently at this time the fungous growth occurs around the margins of earlier scab spots, so that these roughened areas are often seen surrounded by a fresh ring of dark velvety scab growth.

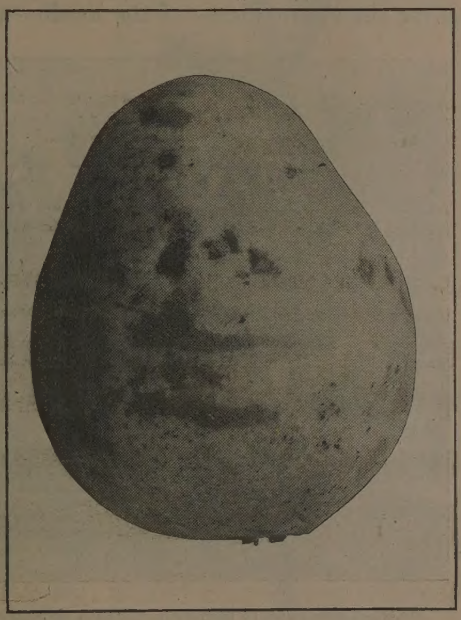

FIG. 3.—Late infection of scab on a Bartlett pear and injury caused by the syneta leaf-beetle. The elongated spots were produced by the beetle.

TREATMENT.

In the treatment of pear scab it is important to dispose of all possible sources of infection, and to this end twig cankers, if present, should be removed in pruning and the infected wood burned. Some disposition should also be made of fallen leaves, which harbor the fungus over winter and which are the most important source of early spring infection. It is impracticable to rake and burn them, and because of their fertilizing value it is not desirable, but early plowing should be practiced and the leaves all turned under before the buds break and expose the flower parts. Such sanitary measures are valuable in connection with subsequent spraying during the summer season, but in themselves are incapable of controlling the disease.

In spraying for pear scab as well as for other fungous diseases the fundamental point to be considered is that spraying is preventive

and not curative in nature; that is, after infection has taken place and the fungus has established its growth in the host, it can not usually be eliminated by spraying. To be most effective the fungicides must be applied before infection takes place; the spray coating must be present before the spores reach the parts that may be infected. The action of such sprays is to inhibit the germination of the spores or to destroy the fungus before it can penetrate the cuticle.

To combat pear scab successfully requires, first of all, efficient fungicides as spray materials; second, thorough spraying, so as to cover all growing parts; and, third, properly timed applications to cover the requirements of the locality and the season. Bearing in

FIG. 4.—A power dusting machine in operation, showing how trees should be covered with dust.

mind the fact that scab infection must be anticipated and that the period of greatest infection is from the time the buds appear until about four weeks after blossoming, it is apparent that during this period the trees should be covered at all times with a protective spray coating. But since scab development is dependent upon moisture conditions it is evident that the number of sprayings must vary with the season.

Among the most efficient fungicides against pear scab are two materials quite universally used, lime-sulphur solution and Bordeaux mixture. Both may be purchased in convenient form on the market, but often may be more economically prepared at home. The former sometimes causes foliage injury, but at a dilution of 1 to 40 it is quite safe to use on pears. Bordeaux mixture is a somewhat stronger

fungicide, but it frequently causes an objectionable russeting when applied to tender young fruits and is in less favor on this account. It is, however, very efficient in controlling pear scab. Sulphur, very finely divided, in the form of an impalpable powder and applied with a dusting machine (fig. 4), is also an efficient fungicide against pear scab, being much more satisfactory in this respect than the commercial Bordeaux dusts that are now on the market.

These general statements concerning spray materials, as well as those which follow in regard to their application, are based upon a series of experimental tests carried out by the Office of Fruit-Disease Investigations of the Bureau of Plant Industry during the seasons of 1915 to 1918, inclusive, at Vancouver, Clarke County, Wash., and at Salem, Marion County, Oreg. The results agree, however, rather closely with those previously obtained, and with well-established usage, in the humid northeastern United States, especially in the Great Lakes region, where pear scab is very severe.

FIG. 5.—A Bartlett pear twig, showing the condition of the buds at the time when the first scab spray, or "delayed dormant" spray, should be applied.

WHEN TO SPRAY FOR PEAR SCAB.

Make the first application for pear scab before the cluster buds begin to separate (fig. 5) and about the time that the first white is seen in the flower buds, using a strong Bordeaux mixture (4–4–50 is satisfactory) or lime-sulphur solution (testing 32° Baumé) diluted 1 to 20. This application is important in those orchards whose immediate past history reveals serious scab infection, especially if early plowing has not been resorted to to dispose of infected leaves on the ground or if twig cankers remain plentiful on

the trees. This application is frequently very valuable when the weather continues rainy and when the fungus may obtain a foothold on the exposed leaves before the time for the next spraying. As the disease is brought under control and the orchard is maintained free from infection, it probably will be found that this application may be

FIG. 6.—A Bartlett pear twig, showing the condition of the buds at the time when the second scab spray, or "pink" spray, should be applied.

eliminated. A practice that has met with favor with some orchardists is to delay the application of dormant-strength lime-sulphur solution (1 to 8) until this time, making what is known as a "delayed dormant" application. However, this procedure involves considerable danger of injury to advanced fruit buds, and can not be considered a safe practice, especially if the buds are pushing out rapidly. If the blister mite is present the "delayed dormant" spray is too late for the best

results against this pest, and the strong lime-sulphur should be applied at the time it will be most beneficial against the blister mite, a separate fungicidal application being made for scab.

FIG. 7.—Bartlett pears, showing the condition of the fruit at the time when the third scab spray, or calyx spray, should be applied.

The second application (corresponding to the "pink" spray in the case of apples) should be made as soon as the buds are separated and showing white, which will be just before blossoming (fig. 6). Either Bordeaux mixture (4–4–50) or lime-sulphur solution diluted 1½ to 50

should be used. At this time all of the outer flower parts are exposed and may be protected by spraying. The period for most effective spraying does not usually exceed three or four days. This is probably the most important single application, especially in a wet season, and should not under any circumstances be neglected, since infection of

FIG. 8.—Sixteen boxes of clean pears and one box of scabby and injured pears from three sprayed trees. The injuries from scab and the syneta leaf-beetle in the box shown were almost negligible from a commercial standpoint, the fruit suffering no discount at the cannery.

the flower stalks at this time is almost certain to cause the fruit to drop.

The third application, known as the "calyx spray," is also highly important and should be made as soon as the petals fall (fig. 7), using lime-sulphur diluted 1 to 40 instead of 1½ to 50. In practice it is best to begin spraying before the petals are all off, if a large acreage is to be covered, since the period for most efficient spraying sometimes does not exceed two or three days after the blossoms fall, depending on the weather conditions. By this time the young pears are fully exposed and must be protected. Infection at this time causes a serious stunting and distortion in the growth of the fruit. For the control of the syneta leaf-beetle lead arsenate should be added to the fungicide, as directed in Table II. Lead arsenate is

valuable not only as an insecticide but in increasing the effectiveness of the fungicide.

A fourth application, in which the same fungicide is used and at the same strength as in the preceding application, should usually follow the "calyx spray" within 10 days or two weeks, in order that the protection of the rapidly growing fruit may be continued. In a dry spring, however, this application is less important and may be omitted.

FIG. 9.—Nine boxes of clean pears and six boxes of scabby and injured pears from three unsprayed trees. The unsprayed fruit included such a high percentage of seriously injured and badly distorted fruit that it was discounted about one-third at the cannery.

Lead arsenate should again be added to the fungicide, to control chewing insects.

The last spray which is generally required should be applied about a month after the "calyx spray." Either lime-sulphur solution, diluted 1 to 40, or Bordeaux mixture (3–3–50) may be used, but the latter is recommended for this application because of the tendency of sulphur sprays to cause injury to fruit and foliage when used during hot weather and intense sunlight. For summer pears, such as the Bartlett, no later spraying ordinarily is necessary in this region, but in the case of varieties that are not picked until after the fall rains begin it is essential to spray again before the rainy period is expected.

By systematically following the spraying schedule here described and concisely outlined in Table II it has been possible to reduce the loss from pear scab to an amount almost negligible from a commercial standpoint (figs. 8 and 9).

INSECT PESTS.

There are several insect pests which cause a great deal of damage to pears in western Washington and Oregon. The methods of controlling these insects vary, and it is therefore essential that the orchardist know what insect is damaging his trees or fruit before attempting to remedy the trouble. Otherwise he may be spending his time and money for nothing. In the following pages the more important species of insects with which the pear grower may be concerned are described separately, together with the injuries caused by each and the methods of controlling it. The greater number of deciduous-fruit insects are most satisfactorily controlled by spraying with an insecticide, the kind of material used and the time of spraying depending upon the insect to be combated. Chewing insects may also be kept in check by the use of poison in the form of a dust, powdered arsenate of lead being most often used.

Of the insects discussed in this bulletin, only one, the syneta leaf-beetle, at present habitually causes serious injury to the fruit. For this reason and because this insect is not as well known as the others it is placed first and is treated more at length, although some of the other insects may at times cause a greater loss by their depredations upon the trees and foliage. As its name implies, this beetle feeds to a great extent upon the foliage, not only of the pear, but of all other orchard trees, and it is able to subsist entirely upon the leaves. However, fruit is invariably attacked when present. The other insects discussed attack the buds, foliage, and bark of the tree, only occasionally directly injuring the fruit.

In addition to the insects treated, various others, such as cutworms and leaf-rolling larvæ, sometimes are the cause of damage, but as these are of minor importance and are almost invariably checked by the spraying program outlined in this bulletin, it is not thought necessary to include them. The codling moth, or apple worm, is a very serious pest of pears in some districts, but has never proved so in the region covered by this bulletin.

On page 34 will be found a table (Table II) summarizing the control measures recommended for the coast regions of Washington and Oregon and showing concisely when and with what materials to spray.

SYNETA LEAF-BEETLE.[1]

The syneta leaf-beetle is a relatively small, elongated insect, with the somewhat hardened wing covers characteristic of beetles (fig. 10). The sexes differ somewhat in size and coloration. The male is a little less than one-fourth of an inch long, and light gray in color, with a light brown head and legs and with a narrow, dusky, or nearly

[1] *Syneta albida* LeConte.

black stripe down the middle of the back. The female beetle is about one-fourth of an inch long, stouter than the male, and ranging in color from a dirty white to a light lemon yellow, yellowish tinted individuals predominating. The head and legs are a very light brown, and occasional specimens are found with a dark stripe down the back, as in the male. The beetles appear in the orchards at about the time the trees are in blossom, coming out of the ground. The first warm clear day about this time will usually bring them out in numbers. They continue to emerge from the ground for 10 days or two weeks, and as they are capable of living for a month or six weeks they will be found in the orchard for about two months after the trees blossom. Most of the damage is done in the first month. There is only one brood in a year, and ordinarily no beetles can be found in the orchards after the first or middle of June.

Upon emerging, the beetles fly directly up into the trees, where they spend most of their time quietly feeding in the folded leaves or on the fruit, being often found in the developing fruit clusters. The holes gnawed in the leaves are negligible compared to the wounds and deformities caused on the fruit by the irregular patches of skin and portions of the flesh eaten off. These wounds are unmistakable on the young pears, no other insect feeding in the same manner or producing such irregular yet shallow cavities (fig. 11). As the pear grows and attains maturity, however, the wounds become calloused and roughened, having to the inexperienced eye much the same appearance as the patches produced by early infections of the pear-scab fungus. It must be remembered that the pear scab does not destroy the skin as the beetle does, but merely ruptures the cuticle or outside layer, and as the pear grows the epidermis thus exposed is left in dried, corky patches over the surface of the injury. This characteristic effect of pear scab is not seen on the spots produced by the beetle, the injured surface in this case having more of a russeted nature, similar to that caused by the rubbing of a twig, as both cuticle and epidermis have been destroyed. (See fig. 3.) The syneta leaf-beetle also frequently feeds on the fruit stems, sometimes eating out large parts of them. This hinders the development of the fruit or causes it to drop. During some seasons 75 per cent of the crop may be injured more or less. A great deal of this injury is of little consequence where pears are sold to canneries, but is important if they are to be packed for the fresh-fruit market. At times, too, 15 or 20 per cent of the pears may be injured so seriously that the canneries will take them only at a reduced rate, such as is paid for pears badly injured by scab. (See fig. 9.) This is in addition to the loss occasioned by the fruit that drops.

FIG. 10.—Syneta leaf-beetles: Male and female. (Much enlarged.)

The beetles ordinarily do not move about a great deal, but are alert for any intruder, and a slight disturbance or shaking of the tree will cause them to drop to the ground, from which they will soon fly to another tree. The spraying or dusting of an orchard usually will cause the beetles to fly out of the trees in some numbers, and their presence will be noticeable to the men operating the machine. The females deposit their eggs by simply dropping them to the ground, where they are practically impossible to find, owing to their small size and inconspicuous appearance. These eggs hatch after several weeks, and the minute larvæ find their way into the soil, where they feed on the roots of various orchard trees. Repeated and thorough search, however, has failed to reveal any larvæ feeding

FIG. 11.—Young Bartlett pears injured by syneta leaf-beetles.

on pear roots, though they were easily found about the roots of apple and prune trees in the same orchard. It seems probable, then, that pear roots are rarely, if ever, injured, and that the beetles damaging pear orchards come largely from other kinds of trees.

In the early spring the full-grown larvæ form cells in the soil, within which they transform to pupæ. This stage lasts about a month, and then the adults emerge. If the weather is unfavorable the adults may remain in these cells until a warm day comes, which accounts for the apparently sudden appearance of these insects about the time the trees blossom.

Treatment.—The syneta leaf-beetle has been the subject of investigation during the seasons of 1916, 1917, and 1918 by the Bureau of Entomology, and it has been found that pears may be protected from damage by the use of an arsenical applied either as

a spray or in the form of a dust.[1] For this purpose arsenate of lead has proved the most satisfactory material to use, and a single application made when most of the petals have fallen (see fig. 7) has given sufficient protection. This should be combined with the third or calyx spray for scab, made at this time. While a single application has been sufficient during the three years that this insect has been experimented upon near Vancouver, Wash., the activities of the beetle may be more prolonged in other localities or during other seasons. If they are found to be causing serious injury at the end of 10 days or two weeks, a second application of poison should be made. This should be combined with the regular fourth scab application. If no scab spray is applied at this time, however, it is very doubtful whether it would pay to apply a special spray for the beetle alone. It would cost nearly as much as the combined spray, and the additional protection gained would not justify this cost under ordinary circumstnaces.

If the trees are to be sprayed arsenate of lead should be added to the fungicide at the rate of 1 pound of powder or 2 pounds of paste to 50 gallons. In practice this has reduced the injury caused by the beetles from 45 to 7 per cent. If a dusting machine is to be used the mixture giving the most complete control is one containing one-third, by weight, of powdered arsenate of lead and two-thirds of superfine sulphur. The use of this mixture has reduced the number of pears injured by the beetle from 45 to 6 per cent. It is a rather expensive mixture, however, and it has been found that by employing a mixture containing only 15 per cent of powdered arsenate of lead and 85 per cent of superfine sulphur, by weight, the injury was reduced from 45 per cent on untreated trees to 13 per cent on those dusted. At the present (1919) price of arsenate of lead the latter mixture would be the most economical to use.

SAN JOSE SCALE.[2]

The San Jose or Chinese scale is an insect infesting the trunk, limbs, and branches of the pear and other trees (fig. 12). The individual insect appears as a small, nearly circular, scalelike object, about one-sixteenth of an inch in diameter. It is grayish in color and somewhat convex, with a darker central elevation or nipplelike projection. This scale is merely the protective covering of the insect, which is soft bodied and yellow in color. When these insects are numerous the bark has a scaly appearance, the tree does not make a proper growth, and the worst infested branches die. As the

[1] A discussion of the relative merits of spraying and dusting will be found on pages 32 and 33.

[2] *Aspidiotus perniciosus* Comstock.

numbers increase the fruit and leaves will be found to be infested, more branches will die, and eventually the whole tree will succumb.[1]

Treatment.—The San Jose scale ordinarily is kept from becoming harmful by a thorough annual application of strong lime-sulphur solution put on when the trees are dormant. Lime-sulphur solution is recommended above any other wash, as it has proved most satisfactory. The commercial concentrated lime-sulphur should be diluted 1 to 8, provided it tests 32° Baumé.[2] This wash should be applied only when the trees are dormant, either after the leaves have dropped in the fall or before the buds have opened in the spring, preferably at the latter time, after the pruning has been done. For good control the trees must be very thoroughly sprayed, care being taken to cover every part, for the insects are only killed by receiving a thorough coating of the wash. Petroleum-oil sprays (p. 28) may also be used, but these sometimes cause injury, particularly to the fruit buds.

FIG. 12.—A pear with San Jose scale. (Much enlarged.)

[1] For further information regarding the San Jose scale, see United States Department of Agriculture, Farmers' Bulletin 650, "The San Jose Scale and Its Control," which will be sent free on application to the Secretary of Agriculture.

[2] As the concentrated material varies it should always be tested with a lime-sulphur hydrometer (see fig. 14). For a table of dilutions and information regarding the preparation and use of the lime-sulphur solution, see page 27.

PEAR-LEAF BLISTER MITE.[1]

The pear-leaf blister mite is a minute creature $\frac{1}{150}$ of an inch in length, and when seen under a good hand lens it is the merest speck. It is not an insect, being more closely related to the spiders, but

FIG. 13.—Apple leaves injured by the pear-leaf blister mite.

for practical purposes it may be considered along with the insects. These mites burrow into the unfolding pear leaves in the spring, causing reddish or greenish blisters or raised spots, which later become brown and dead (fig. 13). Often the infestation is so severe that the leaves do not develop normally and become deformed, later dropping off. The mites also may attack the fruit, greatly disfigur-

[1] *Eriophyes pyri* Pagenstecher.

ing it. These mites pass the winter hidden away beneath the bud scales, crawling forth as soon as the leaves begin to push out of the buds.[1]

Treatment.—As the mites are within the leaf tissues at all times during the summer it is not possible to apply any spray which will affect them at that time. They are readily controlled during the dormant season, however, by a lime-sulphur wash applied as recommended for the San Jose scale. A single thorough application will control both pests, and the work may be most economically done in the early spring after the pruning is finished, when there will be less surface to cover than in the fall. The wash will be most effective if applied after the buds begin to swell but before they open.

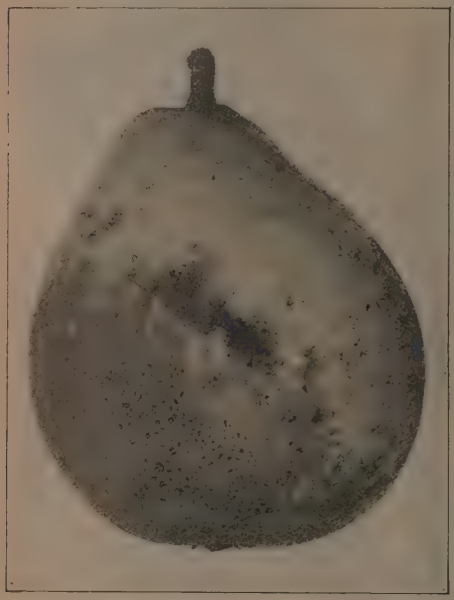

FIG. 14.—Pear showing the work of bud-moth larvæ.

BUD MOTH.[2]

The larvæ of the bud moth are often the cause of considerable injury to pear trees and are particularly destructive on young trees, where a large percentage of the buds may be destroyed. The dark-brown black-headed larvæ or caterpillars hibernate in small silken cases in the crevices about the buds and in the crotches of the fruit spurs. They emerge from these winter quarters when the buds are bursting and bore into the buds. Here they feed for some time, often burrowing into the stem for a short distance. As the leaves and blossoms expand, the larvæ draw them together with silk and develop to maturity in the protection of this nest (fig. 14). Infested bud clusters are easily seen, as some of the leaf stems are usually bitten in two and the leaves turn brown. The caterpillars become full grown in June, when they pupate in the folded leaves, and the moths emerge in July. The caterpillars from the eggs

[1] For more complete information regarding this mite, see United States Department of Agriculture, Farmers' Bulletin 722, "The Leaf Blister Mite of Pear and Apple," which will be sent free on application to the Secretary of Agriculture.

[2] *Tmetocera ocellana* Schiffermüller.

deposited by these moths feed for a time before spinning the silken cases in which they pass the winter. The great damage to pears, however, is done by the caterpillars in the spring, when they prevent many blossom clusters from producing fruit.

Treatment.—The bud-moth caterpillar is somewhat difficult to control, owing to its habit of feeding within the buds and in folded leaves. Under ordinary conditions an application of arsenate of lead with the second scab spray, applied when the blossom buds are well separated (see fig. 6) will be sufficient to control it. However, some of the larvæ will already be within the buds when this spray is applied. Therefore, if it is anticipated that the infestation will be severe it will be necessary to include arsenate of lead with the first or "delayed dormant" scab spray, coming when the buds begin to burst (see fig. 5). If this application for scab is omitted and the bud moth larvæ are numerous, arsenate of lead alone may be used. For either application, use arsenate of lead at the rate of 1 pound of powder or 2 pounds of paste to 50 gallons of liquid.

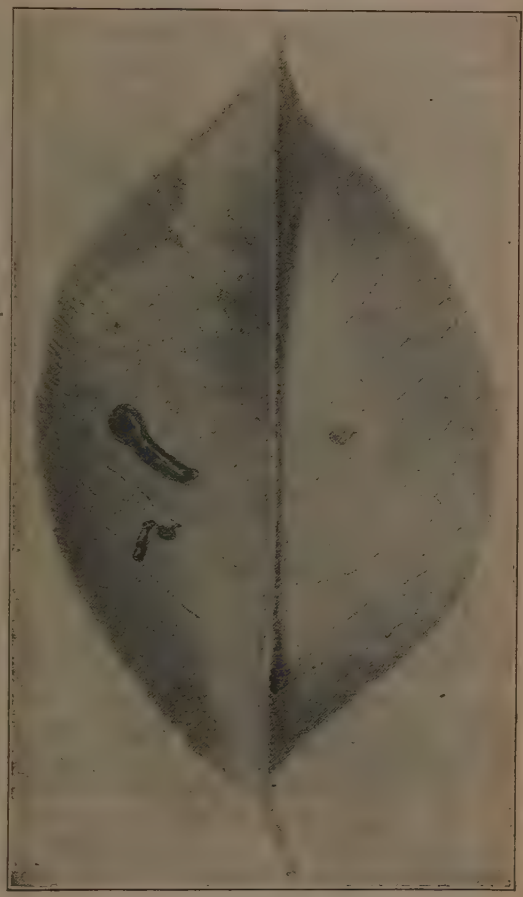

FIG. 15.—Pear slug. (Enlarged.)

PEAR SLUG.[1]

The slimy dark-green or nearly black pear slugs are present on pear trees to a greater or less extent every year (fig. 15). At times they become numerous enough to occasion alarm, and they are

[1] *Eriocampoides limacina* Retzius.

capable of doing a great deal of damage. They skeletonize the leaves, causing them to turn brown, and when the infestation is serious the damage is noticeable some distance away, the trees appearing as though swept by fire. The slugs also occasionally feed on the surface of the fruit, causing deformities and blemishes (fig. 16).

The pear slug is the larva of a small black sawfly which appears in the spring and deposits its eggs in the leaves, where they are easily seen as small, round, somewhat translucent, blisterlike spots. When the slugs are full grown, which is usually early in July, they form cocoons about an inch below the surface of the soil, from which the sawflies later emerge. Two broods occur, the second appearing in August and September, and the slugs of this brood spend the winter in their cocoons, producing adults the following spring.

FIG. 16.—A Bartlett pear injured by pear slug.

Treatment.—The pear slug is easily controlled, being very susceptible to applications of contact insecticides, such as kerosene emulsion or tobacco extract, and also to arsenicals. In commercial orchards the simplest and most economical method of control is a thorough spraying with arsenate of lead, 1 pound of powder or 2 pounds of paste to 50 gallons, to which the slugs succumb very readily. A dust containing arsenate of lead is also very effective. If an arsenical has been applied in May with the fourth scab spray for other insects, the slugs as a rule will be kept in check, but if it is seen that they are going to be numerous, poison should be included with the fifth scab spray or put on as a special application. With the first brood under control, the second brood usually will give no trouble.

PEAR LEAFWORM.[1]

The pear leafworm is a green larva which feeds on the foliage, eating out nearly circular holes in the leaves (fig. 17). These holes give the grower his first indication of the presence of this insect, as the larvæ are the same color as the leaves and usually are overlooked. This is not a serious pest, though instances have been known where it practically defoliated the trees. The worms are the larvæ of a small black sawfly, which is very similar to the adult of the pear slug. Like it, they pass the winter in cocoons in the soil, there being, however, only a single brood. The adults emerge in the spring and deposit their eggs in the unfolding pear leaves, the worms usually being noticeable in May.

FIG. 17.—The pear leafworm: *a*, Leaf showing character of injury and egg *in situ*; *b*, enlarged section of leaf showing egg in tissue and manner of feeding of young larva; *c*, full-grown larva. (*a*, Slightly enlarged; *b*, *c*, much enlarged.)

Treatment.—The pear leafworm is quite easily controlled, arsenate of lead added to the third scab spray usually being effective.

SPRAY MATERIALS.

FUNGICIDES.

In choosing a fungicide for the control of diseases such as pear scab, where the principle involved is the prevention of infection (the protection of the plant), it is well to bear in mind some of the points which determine the effectiveness of fungicide sprays. First of all, the material must have fungicidal value; that is, it must be capable of destroying the fungus when it comes in contact with it. Second, it must retain its effectiveness after the spray dries on the plant. Third, the material must not be injurious to the plant tissues. Fourth, it must adhere after application, so that it is not removed by the first light rain that occurs. The preparation and use of several materials which meet these requirements in the case of pear scab will be briefly described in the following paragraphs.

[1] *Gymnonychus californicus* Marlatt.

BORDEAUX MIXTURE.

Formerly this material was used almost exclusively in spraying for pear scab, and it is still widely used and generally regarded as the most effective fungicide for this purpose. Its use, however, especially on young fruit and in rainy weather, is often attended with a disfiguring russeting of the pears. Since the development of lime-sulphur spray, which causes no such injury, the use of Bordeaux mixture against pear scab has diminished. However, it is a standard fungicide, one by which the results of all other fungicides may be measured, and it will therefore continue in more or less general use. It is especially recommended for the fifth scab spray.

Bordeaux mixture is made of copper sulphate (or "bluestone," as it is sometimes called), lime, and water. The mixture recommended for pear scab in this bulletin consists of 4 pounds of copper sulphate, 4 pounds of stone lime, and 50 gallons of water. In practice it is most convenient to prepare stock solutions of copper sulphate and lime. A stock solution of copper sulphate is made by dissolving it at the rate of 1 pound to 1 gallon of water. It is convenient to make up stock solutions in 50-gallon lots, 50 pounds of copper sulphate being placed in a clean gunny sack and suspended just beneath the surface of an equal number of gallons of water in a barrel (one with wooden hoops is preferable). This will dissolve in about 24 hours, or sooner if hot water is used. A gallon of this stock solution then contains 1 pound of copper sulphate.[1] The lime is prepared by slaking a quantity of stone lime (it should be at least 90 per cent pure) in a measured quantity of water. A smoother paste and a better spray mixture will be obtained if the slaking is begun with hot water, and this is often necessary where poor grades of lime are used. If hot water is used there is also less danger of "drowning" the lime. If cold water is used the action should be started by adding only enough water to cover the lime. As the lime begins to slake it absorbs water and more must be added, it being stirred until a paste is formed, when the remaining quantity of water may be added. If 50 pounds of lime are used it is convenient to add 50 gallons of water to make a stock solution, 1 gallon of which is then equal to 1 pound of lime. After preparation the barrels should be covered if the material is not to be used at once, in order to prevent deterioration.

It was formerly regarded as necessary to dilute both stock solutions and finally mix by pouring them together into the spray tank, but recent investigations have proved that equally good results are obtained by diluting in the spray tank with agitation. The one point to be kept in mind is that the strong stock solutions should never be mixed together. The required amount of either stock

[1] Always stir the stock solution before dipping any out.

solution may be added to the spray tank, a quantity of water then run in, the agitator started, and the other stock solution added. A practice which has several advantages is, first, to add the required amount of the strong copper-sulphate stock solution and then, while running in the water to fill the spray tank, the stock solution of lime may be washed through the sieve. In this way the coarse particles of lime which might clog the nozzles are removed. Equally good results may be obtained, however, when the process is reversed and the copper sulphate added to the lime diluted in the tank. Bordeaux mixture should always be used soon after it is made and never allowed to stand in the tank for any length of time, since it loses its proper physical condition. The spray tank and pump should be thoroughly washed with clean water after Bordeaux mixture has been used.

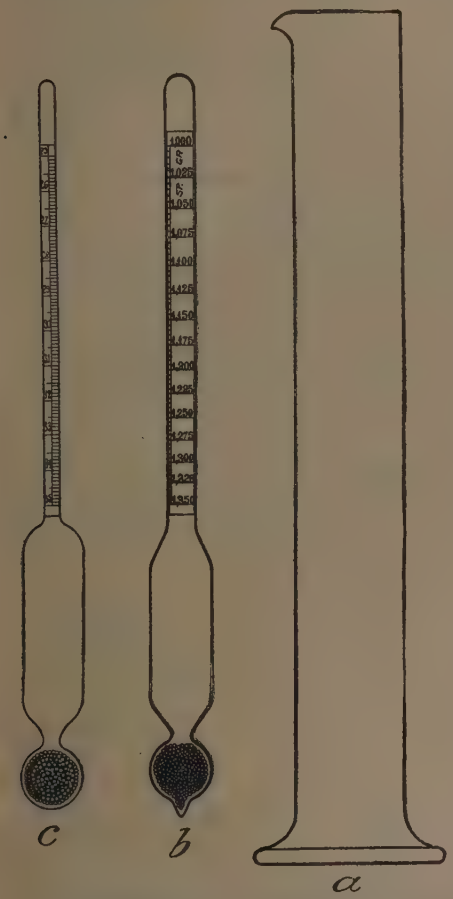

FIG. 13.—Apparatus for determining the specific gravity of lime-sulphur concentrate: *a*, Cylinder for liquid to be tested; *b*, specific gravity spindle; *c*, Baumé spindle.

LIME-SULPHUR SOLUTION.

Lime-sulphur solution has very practical advantages over Bordeaux mixture as a spray for pear scab. It is a very efficient fungicide and may be purchased in convenient concentrated form almost as economically as it can be prepared at home. The severe russeting of the fruit which accompanies the use of Bordeaux mixture under certain weather conditions is avoided by the use of lime-sulphur. It is also cheaper, the price of copper sulphate for the past year or two making the use of Bordeaux mixture almost prohibitive. While there is no doubt that this condition will be adjusted as soon as economic and industrial conditions again become stabilized, it is likely that lime-sulphur solution will remain the more economical

fungicide. Aside from the matter of cost, however, its use is to be preferred on account of the finer finish it imparts to the pears.

Commercial lime-sulphur solution.—There are numerous brands of commercial lime-sulphur solution on the market, and it is usually readily obtainable from dealers in all fruit districts. This commercial stock is reasonable in price, as a rule, of more uniform strength than can be prepared at home, and its use simplifies the spraying operations, since all that is necessary to prepare the spray mixture is to dilute the commercial concentrate with the required quantity of water. The desired strength of spray mixture can be determined by means of a hydrometer test of the concentrated solution. See Table I on page 27 for dilutions.

Homemade concentrated lime-sulphur solution.—For those growers who are equipped with cooking plants or who operate extensively enough to pay for the installation of such a plant, the homemade lime-sulphur solution will be found cheaper and just as effective. Large quantities of the solution may be prepared in advance of the spraying season, when other orchard work is not pressing, and a great economy of time thereby effected. It is difficult, however, to secure a uniform strength in the homemade lime-sulphur solution, and for this reason every batch must be tested with a hydrometer (fig. 18).

In preparing homemade lime-sulphur solution, sulphur and lime are combined in the ratio of 2 to 1; that is, there is twice as much sulphur as lime used. Among the more common formulas for the preparation of lime-sulphur solution are the following:[1]

FORMULA A.

Fresh stone lime	pounds..	50
Commercial ground sulphur	pounds..	100
Water to make finished product	gallons..	50

FORMULA B.

Fresh stone lime	pounds..	80
Commercial ground sulphur	pounds..	160
Water to make finished product	gallons..	50

It is usually desirable to secure as concentrated a solution as possible, and this is accomplished by the use of Formula B. This formula gives a considerable quantity of sludge, but most of it remains in suspension and is not objectionable in spraying.

Directions for preparing lime-sulphur solution.[2]—To make a 50-gallon batch of concentrate, proceed in the following manner:

Place 10 gallons of water in the cooking vessel and start the fire or release the steam. Weigh out the lime and sulphur. The sulphur may be used dry provided all the

[1] For complete information regarding the preparation of homemade lime-sulphur solution, see United States Department of Agriculture Bulletin 197, "Homemade Lime-Sulphur Concentrates."

[2] From Farmers' Bulletin 908, "Information for Fruit Growers about Insecticides, Spraying Apparatus, and Important Insect Pests." This bulletin is a valuable compendium of information for fruit growers and may be obtained free upon application to the Secretary of Agriculture.

lumps are broken, or it may be made into a thin paste, and may be placed in the cooker before or after the lime has started to slake. When the slaking is under way the materials must be stirred vigorously, and this agitation should be continued now and then throughout the boiling. Continue adding water, as required, until the lime is slaked; then, if cooking by fire, bring the contents up to 55 gallons and boil for 50 minutes to 1 hour. When steam is employed fill the cooker up to the 50-gallon mark. No excess water is needed, since the condensation of the steam about equalizes the quantity of water lost through evaporation. The finished product should measure 50 gallons.

After boiling, if it is not to be used at once it should be strained into tight barrels. Each lot should be tested with a hydrometer (fig. 18) when cooled and then diluted according to Table I.

Dilution of concentrated lime-sulphur solution.—To determine the proper dilution for the concentrated lime-sulphur it is necessary to test the solution with a hydrometer (fig. 18). This is an instrument made of glass and is about a foot long. The lower end is weighted with shot, and in the neck there is a graduated scale from which the readings are obtained. Hydrometers are obtainable from dealers in druggists' supplies, and usually from dealers in commercial lime-sulphur solution.

The scale ordinarily employed with lime-sulphur solution is the Baumé, but the specific-gravity scale can also be used. In testing, the clear solution should be used at a temperature of about 60° F. If the sludge has not been filtered out, the contents of the barrel or other container should be thoroughly stirred before removing the sample to be tested. The amount of dilution for concentrates for each degree Baumé from 20 to 36 and the corresponding specific-gravity reading can be determined from Table I.

TABLE I.—*Dilution table for concentrated lime-sulphur solution.*

Degrees Baumé.	Specific gravity.	Number of gallons of concentrated lime-sulphur to make 50 gallons of spray solution.			Degrees Baumé.	Specific gravity.	Number of gallons of concentrated lime-sulphur to make 50 gallons of spray solution.		
		Strength for summer spraying of pears.	Winter or dormant strength.				Strength for summer spraying of pears.	Winter or dormant strength.	
			San Jose scale.	Blister mite.				San Jose scale.	Blister mite.
36	1.330	1	5¼	4¾	27	1.229	1½	8	6¾
35	1.318	1	5¾	5	26	1.218	1½	8½	7¼
34	1.306	1	6	5	25	1.208	1¾	8¾	7½
33	1.295	1¼	6¼	5¼	24	1.198	1¾	9¼	8
32	1.283	1¼	6½	5½	23	1.188	1¾	9¾	8¼
31	1.272	1¼	6¾	5¾	22	1.179	1¾	10¼	8¾
30	1.261	1¼	7	6	21	1.169	2	11	9¼
29	1.250	1½	7¼	6¼	20	1.160	2	11½	9¾
28	1.239	1½	7½	6½					

In winter spraying for the San Jose scale and the pear-leaf blister mite about 5 per cent more of the solution should be used than the table of dilutions shows, if the sludge has not been filtered out. In

summer spraying for pear scab, however, no allowance for sludge is necessary, since a large percentage of this is composed of finely divided sulphur, which is of value.

OTHER FUNGICIDES.

Several commercial preparations which are more or less effective against pear scab are on the market. These include commercial Bordeaux mixtures in the form of pastes and powders, which are prepared for spraying simply by mixing with water. These commercial preparations, while generally efficient, as a rule are not as economical as the homemade mixture. To get the same fungicidal strength it is usually necessary to use them several times as strong as recommended on the label.[1]

Several other commercial fungicides, such as sulphur pastes in various forms and dry powdered combinations of sulphur with barium, lime, and sodium, are also used. In general, they have given fairly good scab control, but at a greater cost than lime-sulphur solution. Injury has also followed the use of some of them, particularly the sodium-sulphur combinations, when used with arsenate of lead.

INSECTICIDES.

Insecticides generally may be classified as contact insecticides, which kill by external contact with the insect, and arsenical poisons, which kill by being taken internally with the food. Insects which obtain their food by means of a sucking beak, such as the San Jose scale, and also the more tender chewing insects, like the pear slug, may be controlled by means of contact insecticides, while for the great majority of chewing insects a poison must be used.

CONTACT SPRAYS.

Lime-sulphur solution.—Lime-sulphur solution, either commercial or homemade, is used more than any other contact insecticide for the control of the San Jose scale and the blister mite. The reader is referred to the discussion of this wash under the heading "Fungicides" (p. 25), which applies equally well to its use as an insecticide.

Petroleum-oil sprays.[2] -Kerosene emulsion is a satisfactory oil spray if carefully made and properly diluted; otherwise it is very likely to injure the trees. *It should on no account be mixed with lime-*

[1] For information enabling one to determine the equivalent copper-sulphate content of commercial Bordeaux mixtures, see U. S. Department of Agriculture, Farmers' Bulletin 994, "Commercial Bordeaux Mixtures: How to Calculate Their Value," which will be sent free on application to the Secretary of Agriculture.

[2] As petroleum-oil sprays are but little used in the region covered by this bulletin and as they possess no particular advantages over the lime-sulphur sprays, directions for preparing them are not included here. Full information will be found in United States Department of Agriculture, Farmers' Bulletin 908, "Information for Fruit Growers about Insecticides, Spraying Apparatus, and Important Insect Pests," which will be sent free on application to the Secretary of Agriculture.

sulphur. Crude-oil emulsion is fully as efficient as kerosene emulsion for a dormant spray. There are also on the market various grades of distillate oil for making emulsions, as well as "miscible" or "soluble" oils to be mixed directly with water.

Tobacco extracts. —Several preparations of nicotine and nicotine sulphate are on the market and are to be diluted with water according to the directions on the package. Of the insects treated in this bulletin, nicotine may be used only for the pear slug, and it is more expensive than arsenate of lead.

ARSENICAL SPRAYS.

Arsenate of lead. —Arsenate of lead is the most widely used poison spray, having largely superseded Paris green. It is much safer to use than Paris green and may be combined with lime-sulphur solution, Bordeaux mixture, oil emulsions, or tobacco extracts. It may be found on the market in either the paste or powdered form. The powdered arsenate of lead is favored by many fruit growers, as it mixes with water more quickly than the paste; is more easily handled, as only half as much by weight is required; and as it may be stored readily without fear of deterioration through loss of water or by freezing.

The paste arsenate of lead contains from 15 to 17 per cent of arsenic oxid, while the powdered form contains from 30 to 33 per cent. The paste, therefore, should be used at 2 pounds to 50 gallons of water, and the powder at 1 pound to 50 gallons. In using the paste the required quantity should first be thoroughly mixed with enough water to form a thin paste, which should then be added to the spray tank of water. The powder may be first mixed with a small quantity of water, or it may be slowly added to the spray material in the tank provided the material is being thoroughly stirred with an agitator.

Arsenate of lime (calcium arsenate). Arsenate of lime, which is similar to arsenate of lead, has recently been found by the Bureau of Entomology[1] to be an effective poison. It is likely to burn trees with tender foliage, but no trouble will be experienced in using it on such trees as the pear or the apple if lime in some form is always added.

Arsenate of lime is fully as satisfactory as arsenate of lead, for it may be combined with lime-sulphur solution or Bordeaux mixture, and it is cheaper than arsenate of lead. Both paste and powdered forms are on the market, the former usually containing 17 to 20 per cent of arsenic oxid, and the latter 40 to 46 per cent. It should be mixed with water in the same way as recommended for arsenate of lead

[1] Scott, E. W., and Siegler, E. H. Miscellaneous Insecticide Investigations. U. S. Dept. Agr. Bul. 278, p. 47. 1915.

and should be used at the rate of three-fourths of a pound of powder or 2 pounds of paste to 50 gallons of water. Unless arsenate of lime is used with lime-sulphur solution or Bordeaux mixture, 2 to 3 pounds of stone lime, slaked in water, should be added to each 50 gallons of spray, to insure against burning.

SPRAYING APPARATUS.[1]

Satisfactory spraying can be done with barrel hand-pump outfits, but such apparatus is efficient only for use in the home orchard, where few trees are to be sprayed. For the larger commercial orchards efficiency and effectiveness in spraying demand the use of only the best power outfits, capable of maintaining a pressure of 200 to 300 pounds while delivering from 5 to 10 or more gallons of spray per minute. Such outfits usually consist of a 2 or 3 cylinder pump driven by an engine of 2 to 4 horsepower, and a tank of 150 to 200 gallons capacity, with an agitator to keep the spray material stirred or in suspension. Larger and more powerful outfits are now available for use in the larger orchards. These outfits have engines of 10 or more horsepower and operate 4-cylinder pumps of large capacity.

There are many kinds of spray nozzles on the market, but they are usually of two types—(1) the Bordeaux and (2) the eddy chamber or whirlpool.

The Bordeaux nozzle may be adjusted to give a relatively fine fan-shaped spray or a coarse driving spray. It has a large capacity, and to insure a satisfactory spray the pump must have ample capacity and maintain a high pressure.

The disk eddy chamber or whirlpool type of nozzle is generally to be preferred to the Bordeaux. It produces a hollow cone-shaped spray. By the use of disks with different sized openings the spray may be varied from a very fine mist to a coarse beating spray. Disk nozzles may be had in either the straight or angled form. The latter throws the spray at an angle from the spray rod and is the most convenient for most spray work. If the straight nozzle is attached to an elbow or nozzle crook the same result can be obtained.

TECHNIC OF SPRAYING.

Whatever the type of sprayer or nozzle used, it must be remembered that the best results can be secured only if the spray is deposited over the entire surface to be protected. In securing this result more depends upon the man doing the spraying than upon the machinery employed. Speed in getting over the trees is usually

[1] For a more comprehensive discussion of spraying apparatus and accessories, the reader is referred to United States Department of Agriculture, Farmers' Bulletin 908, "Information for Fruit Growers about Insecticides, Spraying Apparatus, and Important Insect Pests."

attained only at the expense of efficiency. Speed can be obtained, however, with the large-capacity outfits, and effective control of pests attained at the same time by skillful manipulation of the spray rod. Any part of the tree that is missed may serve as a center from which the scab or insects may spread and propagate. Therefore great care in spraying is necessary for the best results, and only trained men should be intrusted with the work.

One plan, followed by many of the best orchardists with good results, is to station one man on the spray tank to cover the outer portion of the trees and insure the spraying of the tops. The use of a tower in old orchards or with high trees is frequently necessary. A second man follows on the ground with a longer lead of hose, which permits him to work one tree behind, out of reach of the first man's spray. The second man pays particular attention to the interior of the trees and upward spraying against the under surface of the foliage. The outfit is driven between the rows and spraying is done on both rows at once. Only the near half of each tree is sprayed at this time, however, the other half being sprayed when the return trip is made. If the outfit has sufficient capacity the crew may be doubled and progress correspondingly increased.

DUSTING.

The early attempts at dusting as a substitute for spraying were generally unsatisfactory. This was largely due to the fact that the dusts were coarse in texture and an even distribution could not be secured, while at the same time the material would not adhere to the trees. There is now obtainable, however, what is known as "superfine" sulphur. This is sulphur ground to an impalpable powder, so fine that 90 per cent of it will pass through a screen 200 meshes to the inch. Its use involves few of the difficulties encountered in the earlier attempts at dusting. In the experimental work of the Bureau of Plant Industry at Vancouver, Wash., dusting with superfine sulphur gave as good results against pear scab as the lime-sulphur solution in years of light infection, but it was not as good in bad seasons. However, the two methods are not strictly comparable and should not be judged entirely by the same standards.

The dust mixtures of sulphur and arsenate of lead usually employed follow closely one of four general formulas:

FORMULA A.

	Per cent.
Superfine sulphur	50
Powdered arsenate of lead	50

FORMULA B.

Superfine sulphur	66⅔
Powdered arsenate of lead	33⅓

FORMULA C.

	Per cent.
Superfine sulphur	85
Powdered arsenate of lead	15

FORMULA D.

Superfine sulphur	50
Powdered arsenate of lead	10
Hydrated lime	40

The last formula is the cheapest, owing to its dilution with hydrated lime, but in the experimental work it was found that the best results against pear scab and insects were obtained with those mixtures containing a higher percentage of sulphur and arsenate of lead, with lime omitted. Apparently the efficiency of the sulphur dust is affected largely by its physical condition, and this in turn is affected by the character of the diluent material. Powdered arsenate of lead is very finely divided and causes the dust mixture to remain in a fluffy condition and flow readily when poured. It therefore makes a good diluent for the sulphur, while at the same time it is an essential ingredient for the control of chewing insects.

A Bordeaux dust mixture sometimes used against pear scab, which has been tested in the work at Vancouver, Wash., is prepared according to the following formula:

BORDEAUX DUST MIXTURE.

	Per cent.
Commercial Bordeaux mixture, powdered	5.4
Powdered arsenate of lead	13.6
Hydrated lime	81.0

This dust has not given as satisfactory results against pear scab as the sulphur dusts, and it is therefore not recommended.

In small quantities the dust materials may be mixed by hand, but for extensive orchard operations and to get the best mixtures the use of a mixing machine is desirable. A machine which is well adapted for this purpose is a flour mixing and sifting machine, such as is used by millers and bakers.

It was found in the experimental work at Vancouver, Wash., that the quantity of dust required varies somewhat, among other factors, with the conditions of air currents, the size of the trees, and their distance apart. However, it required an average of 1½ to 2 pounds per tree in each application for mature Bartlett pear trees which could be efficiently covered with 3 or 4 gallons of liquid sprays. One of the advantages claimed for dusting over liquid spraying is that the labor cost is much less, it being possible to cover a much larger acreage with a smaller crew in a shorter time than with a liquid sprayer. While this is undoubtedly correct, the lowered labor cost is offset by the much higher cost of the dust materials. These mate-

rials are obtainable only in the East, and the cost of transportation materially adds to the price which the northwestern orchardist must pay for them. On the basis of the quantity of dust required to cover a tree in the experimental work at Vancouver, Wash., and the high cost of the dust materials in the Northwest, it was found that spraying was considerably cheaper, despite the labor saved by dusting.

In a comparison of the methods of application, however, another factor must not be lost sight of—i. e., the element of time and opportunity. Dusting can be done so much more quickly than spraying that it might sometimes insure the application of a fungicide or insecticide when this result could not be obtained with liquid sprays. In the coastal region of the Pacific Northwest, where spring rains are frequently prolonged and likely to occur during part of nearly every day and consequently the ground does not dry sufficiently to permit the hauling of a heavy sprayer, less trouble is encountered with the lighter dusting machine (see fig. 4). With it the orchardist can work between showers, when it would be impossible to use a sprayer, and the great area that may be covered with a dusting machine in a short time might frequently insure a protection of the crop which could not otherwise be obtained. The dusting method must be judged largely in this light, especially until a more extended comparison of the two methods under the conditions in the Pacific Northwest is available. Undoubtedly the dusting machine has advantages that can not be met by the liquid sprayer. At the same time the limitation of the effectiveness of the dust materials at present available and the fact that there is no effective dust for dormant applications do not permit the abandonment of the liquid sprays for all purposes. It is for the individual grower to decide whether he can afford an equipment of both machines, for one can not entirely replace the other, and the liquid sprayer can not be abandoned.

SPRAYING SCHEDULE.

In order that the pear grower may have before him in a concise form the recommendations for spraying pears offered in this bulletin, a condensed spraying schedule is given (Table II). The first column of this table shows the character of the application and the time of applying it, stated in terms of the condition of the trees. The second column specifies the most satisfactory spray material for each application, both for scab and for insects, together with the proper strength to be used. The third column mentions the pests for which each application is used.

TABLE II.—*Spraying schedule for pears in western Washington and Oregon.*

Application and time.	Materials.	Pest controlled.
Dormant spray. Apply when tree is dormant, preferably in spring.	**Lime-sulphur,** 32° Baumé, 1 to 8.....	**San Jose scale and pear-leaf blister mite.**
First scab spray (delayed dormant). Apply when buds are bursting (fig. 5).	Lime-sulphur, 32° Baumé, 1 to 20, or Bordeaux mixture, 4–4–50. Lead arsenate, powder, 1 pound, or paste, 2 pounds, to 50 gallons of spray.	Pear scab. Bud moth.
Second scab spray (pink spray). Apply when blossom buds are well separated (fig. 6).	**Lime-sulphur,** 32° Baumé, 1½ or 2 to 50, or Bordeaux mixture, 4–4–50. Lead arsenate, powder, 1 pound, or paste, 2 pounds, to 50 gallons of spray.	**Pear scab.** Bud moth.
Third scab spray (calyx spray). Apply as soon as most petals have fallen (fig. 7).	**Lime-sulphur,** 32° Baumé, 1 to 40..... **Lead arsenate,** powder, 1 pound, or paste, 2 pounds, to 50 gallons of spray.	**Pear scab.** **Syneta leaf-beetle** and pear leafworm.
Fourth scab spray (10-day spray). Apply 10 days or two weeks after calyx spray.	Lime-sulphur, 32° Baumé, 1 to 40..... Lead arsenate, powder, 1 pound, or paste, 2 pounds, to 50 gallons of spray.	Pear scab. Syneta leaf-beetle and pear slug.
Fifth scab spray (30-day spray). Apply 30 days after calyx spray.	**Bordeaux mixture, 3–3–5, or Lime-sulphur,** 32° Baumé, 1 to 40. Lead arsenate, powder, 1 pound, or paste, 2 pounds, to 50 gallons of spray.	**Pear scab.** Pear slug.

Since it is not always necessary to apply all of the five scab sprays or to spray for all the insect pests mentioned, a distinction has been made in the table between the more important and the less important applications. The more important applications are printed in heavy type, namely, the *dormant spray*, the *second scab spray*, the *third scab spray*, and the *fifth scab spray*. The materials to be used and the pests controlled by these sprays are also indicated by heavy type. Under most conditions these four sprays should be applied to insure maximum returns from the trees, and it is believed that a consistent spraying program involving the use of these four applications will suffice in most cases. In orchards that have been neglected or carelessly sprayed it will be necessary to include the first scab spray until the disease is brought under better control, and in a wet season the fourth scab spray should also be included. The various insects whose names appear in light type are more numerous in some seasons than in others or occur more commonly in some localities than others. Hence local and seasonal conditions will have to determine whether or not they should be sprayed for.

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